IEEE Spark

IEEE

ENGINEERING INSIDE:

2015 ISSUE 4

SMART BUILDINGS

Building Smart

November 2015

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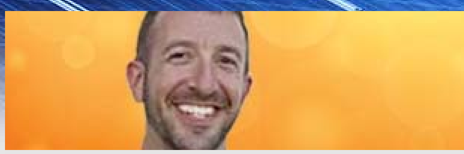

Meet Chris Steffens!

November 2015

Chris Steffens is an architectural lighting designer and energy consultant in New York City, and a Visiting Assistant Professor in the Schaefer School of Engineering and Science at Stevens Institute of Technology, Hoboken New Jersey. Currently, he is advising the Stevens "SURE HOUSE" team at the U.S. Department of Energy Solar Decathlon 2015 competition in Irvine, California.

Build a Passive Solar House

November 2015

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Smarty Pants

See what the Spark crew is up to in this issue!

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Want to make your home smarter? With your parents' permission, try out a home automation project.

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In the latest issue of IEEE Spark, get a glimpse into the world of smart buildings! Learn about the technologies that are creating efficiencies where we live, work, and play; meet an innovator in smart building design; build a passive solar house; and learn how you can make your own home smarter.

Read this issue!

Building Smart

November 2015

by Robin Hegg

Take a minute to think about all the energy and electricity that gets used everyday in your home and your school. Lights are turned on throughout the day and night, air conditioning cools the air inside during the summer and heat warms it in the winter, water is heated and cooled, appliances and devices like refrigerators, stoves, computers, and televisions run, and mobile devices like cellphones and tablets are charged.

An incredible amount of the electricity we use every day comes from the buildings where we live, work, and learn. The United States Department of Energy reports that 4.8 million commercial buildings and 350,000 industrial facilities in the US are responsible for about half of the country's total energy use, and buildings consume about 70% of the electricity in the United States. Not only do buildings account for a huge percentage of our energy and electricity use, the DOE estimates that 30 percent of that energy is used inefficiently or unnecessarily. According to the Royal Academy of Engineering in the UK, "smart buildings will be crucial to maintaining quality of life as urban populations rise and natural resources dwindle." Making buildings more energy efficient has the potential to incredible amount of energy.

Smart buildings aim to do just that. By connecting building systems and appliances and collecting and analyzing data about energy usage, occupancy, and external conditions like weather, smart buildings have the potential to save energy, money, and make people more comfortable in the process. A building could adjust window blinds according to the sun's position in order to optimize natural light, limiting the use of electrical lights and heating the house without the use of electric heating systems. It could use patterns of room usage to heat and light areas of the building only when in use or in anticipation of use. This collection of networked objects is referred to as the Internet of Things (IoT).

Smart buildings can respond to the data they collect and use this data to anticipate the needs of its occupants. For instance, if a building's occupants wake up at the same time every day, a smart building might have the blinds open at that time, or have the lights slowly brighten. It could turn on the heat before everyone wakes up and get the coffee machine started.

A smart building's systems and smart devices are controlled by a building management system or BMS. The BMS is the building's owner or manager centralized way to manage the building's activities. The BMS gathers information from the building's sensors and makes decisions about how to adjust the building's systems.

In addition to lighting and heating systems, smart buildings can also monitor and adjust security and fire alarms, elevator systems, and plumbing. Smart buildings can also be set up to monitor their own structural safety, alerting occupants if a pipe leaks or a wall becomes structurally unsound.

While new buildings are being designed with smart technology, it's also important that existing buildings be retrofitted with smart technology. Since existing buildings account for such a large amount of energy consumption, making existing buildings more energy efficient could save an incredible amount of energy. The initial cost of upgrading a building could be quite steep, but owners would save money in the long run.

The existing buildings in the United States that account for almost half the country's energy use total about $202.3 billion in energy costs. In addition to general energy cost savings, there is the potential for communication with energy companies that could allow buildings to sell back energy they produce, or to sell energy savings to companies. Energy companies, anticipating an upcoming heat wave and influx of energy use, could offer to pay buildings in exchange for a decrease in their energy usage. EDF Energy, a UK utility company, aims to have installed smart meters in 100 percent of its customers' homes by 2019. Homes will be outfitted with kits that include gas and electricity meters, an in-house display, and a communications hub that will allow customers to view data remotely and link with the utility company's systems. Increasing communication between utilities companies and buildings like this means a smarter power grid is needed. A smart grid would allow utility companies and buildings to communicate directly and in real time.

All of these reasons are why the Obama administration launched the **Better Buildings** initiative in February of 2011. The Better Buildings initiative "aims to make commercial, public, industrial, and residential buildings 20% more energy efficient over the next decade." The initiative partners private and public sector organizations to share energy saving technology and successes. **Green Button**, a government and private energy industry-led effort, focuses on utility companies and consumers, working to increase energy efficiency by making energy use data available to owners and building managers in a user-friendly manner, helping them to set and meet energy saving goals.

There are many challenges to reaching the full potential of smart building technology, however. All the data being collected from building systems and appliances means a lot of information needs to be uploaded and processed, which requires wireless networks that can handle the increased data affordably and effectively. In order for appliances and devices to be able to communicate with one another and with the building's management system, they also need to be designed in a way that allows them to work together cooperatively and be swapped out and upgraded as needed. Recent IEEE standards have helped set a foundation for this type of networking. The adoption of open standards such as BACnet, Modbus, and LonWorks have made it possible for every manufacturer and contractor to make a contribution to a smarter whole.

Security is also a major issue facing the future of smart buildings. Hacking is an issue, meaning smart building systems need to be built with security in mind and with the ability to be updated to address new threats. Smart buildings and the Internet of Things also raise concerns about privacy. A large amount of data will be collected and this data has to be stored and treated securely. Consumers need to be able to trust that their information is safe.

The more human challenge to smart buildings is making sure that the people who will occupy these buildings feel comfortable and are able to trust the technology around them. People need to feel that they are still in control of their environment, interfaces must be user friendly, and systems must be reliable.

Smart buildings offer the possibility of a more comfortable, streamlined living environment while at the same time promising energy and cost savings. The movement toward smart buildings could have a very positive impact on the environment, helping people to stop wasting energy without losing comfort.

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Meet Chris Steffens!

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I am an architectural lighting designer and energy consultant in New York City, and a Visiting Assistant Professor in the Schaefer School of Engineering and Science at Stevens Institute of Technology, Hoboken New Jersey. Currently, I am advising the Stevens "SURE HOUSE" team at the U.S. Department of Energy Solar Decathlon 2015 competition in Irvine, California.

CHRIS STEFFENS

Having spent 10 years in the entertainment lighting and controls industry, I gained tremendous breadth of experience working in the field, on the bench, and as a project manager. I most enjoyed lighting architecture and public spaces, so I returned to school for a Masters of Fine Arts in lighting design from Parsons School of Design at the New School in New York City. My current work is primarily focused on the impact of light and energy on the built environment. I work with engineers, architects, and lighting firms designing and optimizing buildings for daylight, electric lighting systems, and photovoltaic arrays.

1. Why did you choose to study the engineering field?

I have always been interested in the positive impact engineering and technology can have on people and on the planet. My undergraduate work was centered on product design for manufacture, technology transfer, and manufacturing engineering technology. Our factories, homes, and businesses account for nearly half of our primary (source) energy consumption here in the United States. If we are to mitigate the effects of climate change, we need to shift our energy economy to more efficient systems and methods. I feel very fortunate that every day I am able to make positive design and engineering decisions involving energy efficiency and renewable energy.

LED LIGHTING SOURCES ARE NOW LEADING THE WAY IN EFFICACY (LIGHT OUTPUT FOR A GIVEN POWER INPUT) AND COLOR RENDERING QUALITY. LOW VOLTAGE LED TRACK LIGHTING WAS INSTALLED IN THE STEVENS SURE HOUSE PROJECT. CREDIT: JUAN PAOLO ALICANTE

2. What do you love about engineering?

From design through to construction, every project develops a unique personality. Optimizing each building is an investigative engineering and design challenge. For example, at the beginning stages of the design process, I may spend many hours creating a

USEFUL LINKS:

Sure House
Solar Decathlon

EDUCATIONAL BACKGROUND:

MFA, Lighting Design, Parsons School of Design - The New School
B.S., Wheeling Jesuit University

ADVICE TO STUDENTS:

It's safe to say that most engineering, design, and architecture firms are actively seeking talent in the energy efficiency and renewable energy fields. These companies can be small firms or large organizations. Think about the type and size of work environment from which you might gain the most at the beginning of your career...

computer model to allow the design team to better understand the seasonal effects of weather and sunlight on the building. Using computer simulations, I will test several versions of building systems, including windows, active and passive heating and cooling strategies, and photovoltaic array designs. I am always exited to measure and observe the finished building, because the results allow me to refine my modeling and make the next project even better.

3. How did you first get involved with "Smart" homes or buildings? Share a project or inspiration with us please…

STEVENS INSTITUTE OF TECHNOLOGY'S "SURE HOUSE" FEATURES TWO DISTINCT PHOTOVOLTAIC SOLAR ARRAYS, POWERING ITS APPLIANCES, PROVIDING ENERGY FOR ELECTRIC VEHICLE CHARGING, AND HEATING DOMESTIC HOT WATER. IN THE EVENT OF A NEIGHBORHOOD POWER OUTAGE, SPECIAL ELECTRONICS AND SWITCHING SYSTEMS ACTIVATE TO ALLOW THE HOME TO SAFELY DISCONNECT FROM THE UTILITY AND CONTINUE TO PRODUCE POWER TO CHARGE PHONES AND POWER SMALL APPLIANCES. CREDIT: JUAN PAOLO ALICANTE

My graduate thesis project was a Solar Decathlon home called "Empowerhouse" – a zero net energy home designed for a first-time homeowner and an affordable homebuilder. In regards to the "smart" systems in this home, the premise was not to overwhelm the family with extraneous technology or features. We were able to include some sophisticated and inexpensive controls features that made the home easy to operate and energy efficient. The lighting controls and "smart" features, such as fresh air ventilation with heat recovery, were tied together with wireless, battery-less switches and relays, all operating without complicated home automation systems. The lighting fixtures were attractive and capable of being made by volunteers.

4. Is there a particular application or industry that you think could benefit the most from "Smart" building advances in the future?

SURE HOUSE'S INTERIOR IS SPACIOUS, BRIGHT, AND INVITING. CREDIT: JUAN PAOLO ALICANTE

Because we spend so much of our time in our homes and at work in buildings, wireless network interconnectivity to various building systems and appliances such as lights, thermostats, and hot water heaters will continue to be an area of big innovations in the home electronics industries. The power systems engineering fields will also benefit from interconnected devices – everything from batteries, demand response systems, your electric vehicle, and local utility infrastructure one day may be freely communicating.

5. You work with many students when developing a Smart Home….what are the rewards and challenges of working with students on this type of effort?

The most rewarding teaching moments for me have been those times when students

realize they have applied engineering principles learned in the classroom to bring a project from concept to reality. For most projects, only the strongest concepts make it through to completion, because they are developed and refined by a large interdisciplinary team of design and engineering students. The engineering students are involved in the design process at the start of the project, and as a result the design students are able to incorporate more rigorous performance-based analyses. This process is challenging but important!

6. What challenges do we face in the area of "Smart" homes and structures? What's the biggest obstacle at the moment?

Key inventions like the telephone and the internet in the 20th century brought us into the "information age." The 21st century has brought us to an "interconnection age," where the challenges are not just to ask "how" we connect devices and people to information, but "why?" Where are the opportunities for mutually beneficial interactions? Your electric vehicle may connect to your home appliances and to the utility grid, storing solar energy for nighttime consumption, waiting to charge based on utility demand, responding by discharging to the grid to help the utility manage power and frequency. The complexity of these interconnected device relationships will require a multitude of power systems and electronics innovations.

THE U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON COMPETITION BRINGS STUDENTS AND PROFESSIONAL ADVISORS TOGETHER IN THE FIELD TO DESIGN AND BUILD AN AFFORDABLE, ATTRACTIVE, AND INNOVATIVE SOLAR-POWERED HOME. FROM LEFT TO RIGHT, STEVENS ELECTRICAL ENGINEERING STUDENTS ALEX CARPENTER, AJ ELLIOTT, AND GREG PUTLOCK, STEVENS FACULTY CHRISTOPHER STEFFENS, AND MASTER ELECTRICIAN JOHN KIYLER.

7. Whom do you admire and why?

I believe the greatest engineering challenges of this century are addressing climate change and providing energy services to our growing world population. For that reason, I admire my students and their peers. They are passionate about designing and engineering energy efficiency and renewable energy solutions for buildings and cities.

8. How has the engineering field changed since you've started?

I could not have imagined how quickly LED sources would come to dominate the lighting

industry. Color quality and lumen output are steadily improving. I'm excited and encouraged to see the number of women in the engineering field steadily increase. Finally, the pace of the building design process has become so fast and so very challenging for engineers and designers; teamwork is a must!

ALL-LED LIGHTING AND WIRELESS CONTROLS PROVIDED SURE HOUSE WITH A FLEXIBLE AND DYNAMIC NIGHTTIME PRESENCE. THE CONTROLS SYSTEM FOLLOWS PATTERNS OF SUNRISE AND SUNSET, AUTOMATICALLY ADJUSTING THE WARMTH OF THE LIGHTING FIXTURES IN THE KITCHEN AND BATHROOM BASED ON THE TIME OF DAY. CREDIT: JUAN PAOLO ALICANTE

9. What's the most important thing you've learned in the field?

Never waste an opportunity to document, measure, and observe your work. Photographs, logged data, and concise notes are the most important sources of information you can use to better understand how and why a building is performing the way it's designed (or not). The next project will incorporate these learned moments, and be a better building.

10. What advice would you give to recent graduates interested in working in the "Smart" arena?

It's safe to say that most engineering, design, and architecture firms are actively seeking talent in the energy efficiency and renewable energy fields. These companies can be small firms or large organizations. Think about the type and size of work environment from which you might gain the most at the beginning of your career. There are advantages and disadvantages to gaining experience at a small office, as there are working for a national or international firm with many staff and areas of practice.

11. If you weren't in the engineering field, what would you be doing?

Though I really enjoy working in and around high performance buildings, I also enjoy exploring far away from the constructed environment, so I would probably be involved in field ecology or some other aspect of environmental science.

GOOD PLANNING, COMMUNICATION, AND COLLABORATION AT EVERY STAGE OF A PROJECT IS KEY. DURING CONSTRUCTION, WE ESTABLISHED PROCEDURES FOR SAFE WORK, REVIEWED DAILY TASKS, AND KEPT EACH OTHER INFORMED OF ANY CHANGES OR ISSUES. CREDIT: JUAN PAOLO ALICANTE

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Make Your Home Smarter

November 2015

by Robin Hegg

Want to make your home smarter? With your parents' permission, try out a home automation project. Affordable, open-source computer platforms like **Arduino** and **Raspberry Pi** can make it possible for you to add smart home technology to your home. You can connect these computers to your appliances, giving you the power to control them remotely and to network them to a central system.

Use one of the online tutorials listed below, make up your own, or give **Smart Living Maker** a try.

Smart Living Maker is an online tool that helps you to connect and automate the devices you've connected with Arduino or Raspberry Pi. It provides a Building Management System (BMS) style dashboard you can access from your computer or phone and makes it easy to set up "when-then" style rules for your devices to follow.

Here are some other project ideas to get you started:

6 Smart Home Projects You Can Take on this Weekend

Instructables: Smart Home with Arduino

Instructables: Arduino Controlled Smart Home

lifehacker: Build an Entire Home Automation System with a Raspberry Pi

Raspberry Pi Blog: Home Automation

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Build a Passive Solar House

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by Robin Hegg

Smart buildings use technology to make our indoor environments as energy efficient and comfortable as possible. But a building's initial design can have a major impact on energy efficiency. In this activity, you will design and build a passive solar house. Passive design uses no mechanical or electrical devices of any kind, but uses design, orientation, and carefully selected materials instead. Designing an energy-efficient home means making optimal use of the natural heating power of the sun.

Passive solar design uses different materials and design elements to keep a building cool during the summer and warm in the winter. It also makes use of the sun's angle in the sky at different times of the day and of the year through a building's placement, the placement of windows and doors, and materials that can absorb or reflect the sun's heat.

If you're doing this activity when it is cooler outside, your house will need to use the sun to heat the inside of the house. If you're doing this activity when it's warmer outside, the house will be built to limit temperature increase.

Your house must include four walls, a roof, two working doors, and a window. It should be at least 15 cm high with an area of at least 30 cm. You'll need to leave room inside for a thermometer to be placed so temperatures can be recorded.

Materials

Cardboard or cereal boxes

Construction paper

Plastic cups

Sand

Stones

Water

Rulers

Tape

DID YOU KNOW?

Intel recently debuted the Smart Tiny House, a "living lab exploring the smart home of the future."

The Microbot Push, a robotic finger, can turn any device with a button in your home into a smart device.

Deloitte's new smart office building in Amsterdam, known as the Edge, is outfitted with 40,000 sensors!

FIND OUT MORE:

You can also visit **TryEngineering.org** to explore other engineering activities and resources. Additional activities and lessons can be found **here**.

Plastic wrap

Felt

Light and dark tempera paint

Foliage

Compass

Thermometer or temperature strips

Protractors

Scissors

Pencils

Steps

1. Using what you know about the sun's position, heat absorption and reflection, and what you've learned about smart buildings and passive solar design, design your solar house. Think about what materials and colors you will use and remember to think about how you will position your house in relation to the sun. If you want more information on the sun's angle, check out **http://www.susdesign.com/sunangle**.

2. Construct your house using the materials available. Include a window. You will use the window to view the thermometer. Use plastic wrap to seal the window.

3. Place your house outside at midday. Use a compass to make sure your house is placed in the position you planned.

4. Place a thermometer inside your house and record its starting temperature. Continue to test and record the internal temperature of your house every 2 minutes for 12 minutes.

5. Move your house to a shaded area and test the temperature every 2 minutes for another 12 minutes.

6. If you have time, open your house's window by removing the plastic wrap and repeat step 5 to test the temperature again. Compare the results.

Questions

1. Did your solar house successfully increase the internal temperature or keep it cool (depending on the time of year)?

2. What materials do you think were most helpful to your house's design?

3. What materials outside of those that were available do you think would have helped your house to better cool or heat itself?

4. Having tested your house, would you change your design? What design or material changes do you think would help your house to work better?

5. If you were to turn your passive solar house into a smart house, what features would you add? How do you think smart building technology could help to make even better use of the sun's energy?

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Collaborating for a Smarter Future

November 2015

by Robin Hegg

With members across all disciplines of engineering, IEEE has a unique ability to foster collaboration and innovation. In the field of smart buildings, the IEEE is setting standards, researching across disciplines, and encouraging the growth and development of new technologies through professional collaboration.

One of the IEEE's roles is to set standards in electronics and networking. Some of these standards have provided the foundation for networking many devices, allowing devices from different manufacturers to be networked together, and helping to ensure that new building technology maintains the health and safety of building occupants.

The **IEEE Robotics & Automation Society**'s has a **Smart Building Technical Committee** that takes advantage of IEEE's reach across many different fields of engineering. Since smart building technology and building energy efficiency involve multiple fields of study, IEEE RAS's Smart Building Technical Committee works to promote cross-disciplinary research. Conferences and newsletters help smart technology professionals share their research, allowing other professionals to learn about the latest developments in smart building technology.

Developing the smart grid is a vital part of in the growth of smart technology. But growing the smart grid means developing new communications and control capabilities, energy sources, and adherence to complicated regulations. It will also require cooperation and collaboration of engineers across disciplines. IEEE has created **IEEE Smart Grid**, which works to provide "expertise and guidance for individuals and organizations involved in the modernization and optimization of the power grid," bringing together professionals from different disciplines to encourage the advancement of smart grid technology.

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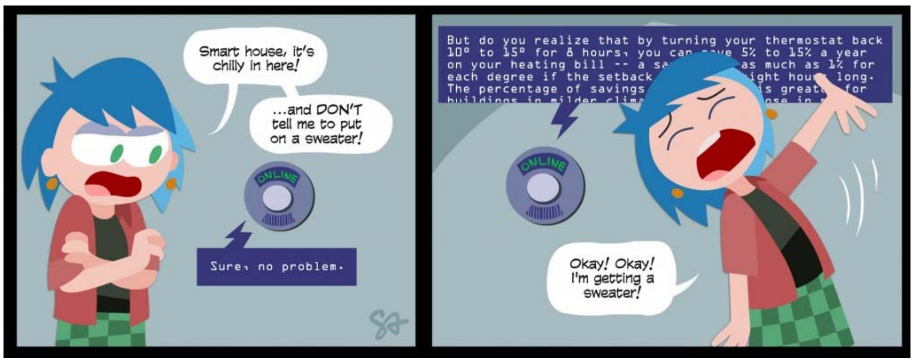

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IEEE Spark Challenge: Smart Buildings

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1) Which is not something that can be controlled in a smart building?
   a. Appliances
   b. Locks
   c. Heating
   d. Pet feeding
   e. None of the above

2) A smart building is controlled centrally by a BMS which stands for:
   a. Balanced Mathematical Signal
   b. Base Main Setup
   c. Building Management System
   d. Better Maintenance System

3) What percentage of electricity is consumed by buildings in the U.S.?
   a. 70%
   b. 60%
   c. 50%
   d. 80%

4) A system that uses information technology to deliver electricity reliability, securely, and efficiently is known as:
   a. Substation
   b. Smart Grid
   c. Power meter
   d. The Internet of Things

5) Which of the following are examples of sensors that could be found in a smart building?
   a. Temperature
   b. Pressure
   c. Humidity
   d. Light
   e. All of the above

6) A house that consumes little or no energy is also known as a:
    a. Biodegradable house
    b. Passive house
    c. Radiant house
    d. Active house

7) The Sure House developed by the Stevens Institute of Technology is fully solar powered:
    a. True
    b. False

8) Which is not a potential challenge of introducing smart building technology?
    a. Security
    b. User-friendliness
    c. Cost of setup
    d. Pollution

9) The network of physical objects embedded with technology that allows them to collect and exchange data is known as:
    a. The Internet of Things
    b. Big data
    c. Cyber security
    d. Software Defined Network

10) A document that establishes norms and requirements to ensure that products work effectively, compatibly and safely is also known as a:
    a. Boilerplate
    b. Heuristic
    c. Technical standard
    d. Golden rule

IEEE Spark Challenge: Smart Buildings

Answer Key

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